(12) UK Patent Application (19) GB (11) 2 121 239 A

(21) Application No 8213884
(22) Date of filing 13 May 1982
(43) Application published
14 Dec 1983
(51) INT CL^3
H01P 1/15
(52) Domestic classification
H1W 3A2 7 CX
U1S 1834 2147 2205
H1W
(56) Documents cited
None
(58) Field of search
H1W
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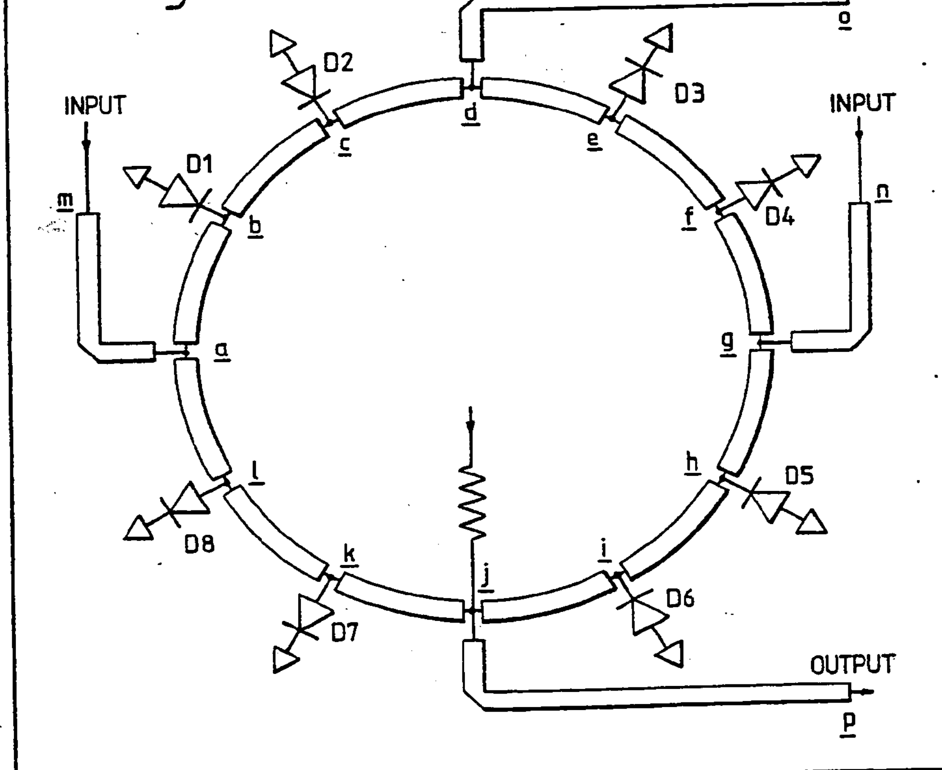
(54) A solid state change-over switch for microwave signals

(57) A solid state changeover switch for microwave signals comprises 4*n* identical transmission lines *a—b*, *b—c*, *c—d* . . . *l—a* electrically connected in series. Each line has a length $\lambda/4$ where λ is the incident signal wavelength. Nodes *a* and *g* are connected to input ports and nodes *d* and *j* to output ports. Each of the intervening nodes *b, c, e* . . . *l* is connected to ground via a PIN diode D1, D2, D3 . . . D8. Diodes D1, D2, and D5, D6 in the first and third quadrants are oppositely poled to diodes D3, D4, D7 and D8 in the second and fourth quadrants. When a positive control bias is applied to the ring D1, D2, D5, D6 are biassed "off" and allow signals to pass from *a* to *d* and from *g* to *j*. When a negative bias is applied signals pass from *a* to *j* and from *g* to *d*.

Fig.1.



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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Fig.1.

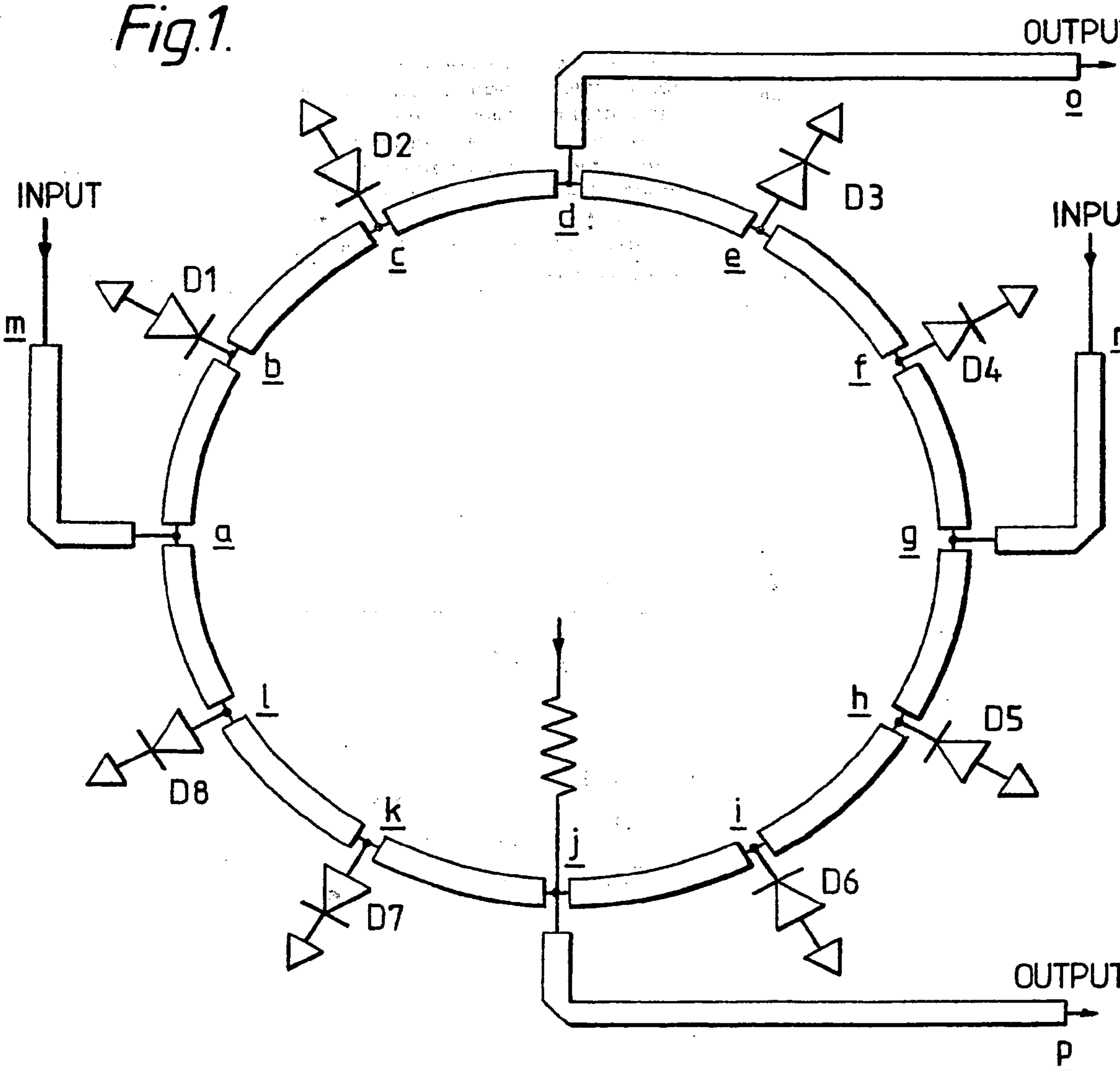


Fig.2.

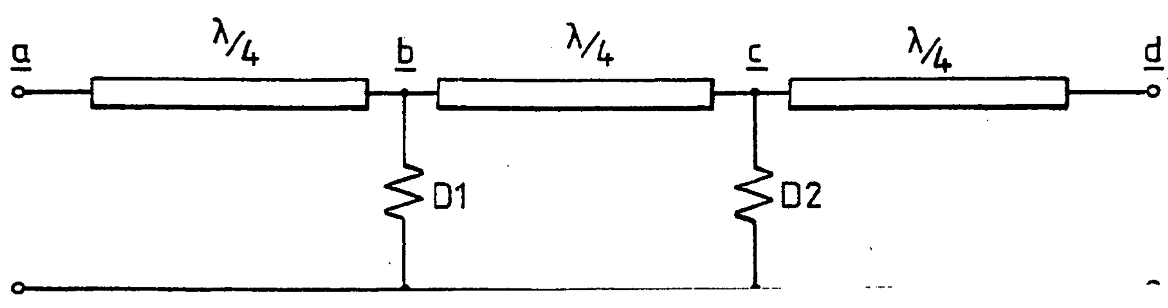
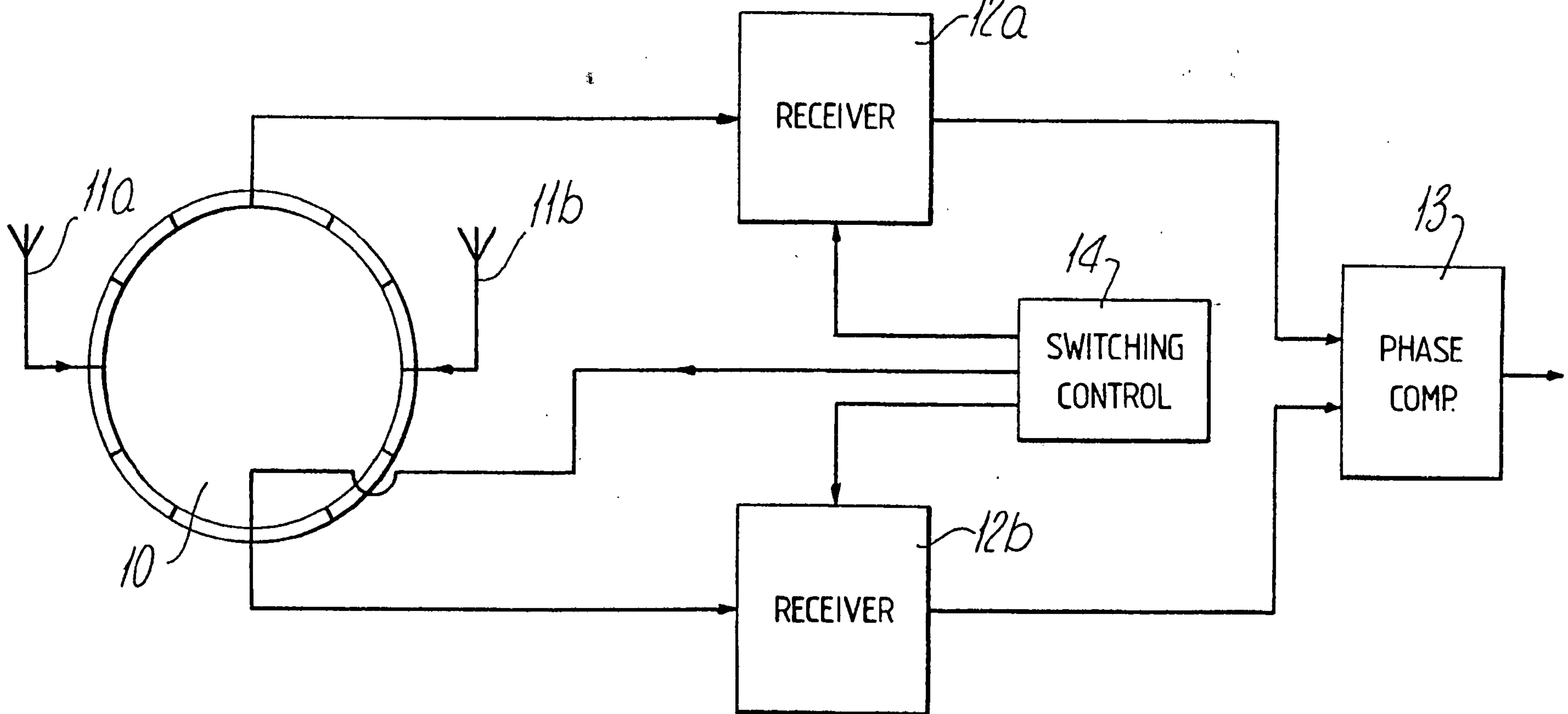


Fig.3.


11a
11b
10
RECEIVER
12a
RECEIVER
12b
SWITCHING CONTROL
14
PHASE COMP.
13

SPECIFICATION

A solid state change-over switch for microwave signals

This invention relates to a solid state switch for microwave signals, and is particularly suited for Navstar receiver applications.

In an azimuth determining Navstar receiver there is a requirement for a microwave change over switch with prescribed performance features relating to the precise measurement of differential phase between two receiver tracking channels. This differential phase must be measured with minimal induced phase error.

According to the present invention there is provided a solid state change-over switch arrangement for microwave signals comprising $4n$ identical transmission lines each of length $\lambda/4$, where λ is the incident signal wavelength, electrically connected in series in a ring configuration, with two input ports connected to two opposing nodes on the ring and two output ports connected to two opposing nodes on the ring, the input nodes being disposed orthogonally with respect to the output nodes so that each input node is electrically connected to each adjacent output node by a quadrant of n transmission lines, n being not less than 2, $4n$-4 PIN-diodes each connecting one of the nodes intermediate the input and output ports to ground, with the diodes in one pair of opposing quadrants being oppositely poled with respect to the diodes in the other pair of quadrants, and means for applying a control bias potential to the ring to effect switching of the diodes.

An embodiment of the invention will now be described with reference to the accompanying drawings, in which:—

Fig. 1 illustrates schematically a solid state change-over switch,

Fig. 2 illustrates an equivalent circuit for a single quadrant of the switch configuration, and

Fig. 3 illustrates the application of the switch in a direction finding equipment.

The change-over switch shown in Fig. 1 comprises 12 identical $\lambda/4$ transmission lines *a*—*b*, *b*—*c*, *c*—d . . . *1*—*a* electrically connected in series in a ring configuration. Identical input transmission lines *m*—*a* and *n*—*g* are connected to provide input ports to nodes *a* and *g* of the ring. Identical output transmission lines *d*—*o* and *j*—*p* are connected to provide output ports to nodes *d* and *j*. The ring is thus effectively divided into four quadrants each having three transmission lines in series with two intermediate nodes, e.g. the quadrant between *a* and *d* has intermediate nodes *b* and *c*. The intermediate nodes in each quadrant are connected to ground by PIN diodes D1—D8. The diodes in opposing quadrants *a*—*d* and *g*—*j* are oppositely poled to the diodes in the other pair of quadrants *d*—*g* and *j*—*a*. A control bias potential is applied to the ring at a suitable point, e.g. node *j*.

Consider now the quadrant *a*—*d* as shown in Fig. 2, with a signal input at *a* and output at *d*. If a positive potential control bias is applied to the ring, diodes D1 and D2 will be biassed "off", and the signal travels from *a* to *d* with a minimal insertion loss defined by the losses for the medium in which the $\lambda/4$ lines are realised and the small parasitic effects introduced by the diodes.

With the diodes D1 and D2 biassed "on" by the application of a negative potential control bias the input signal at wavelength λ incident at node *a* is presented with a high impedance path to *b* by virtue of the substantial short circuit to ground of the $\lambda/4$ line *a*—*b*. Any residual signal at wavelength which succeeds in propagating to node *b* will again be presented with a high impedance path to node *c* by virtue of the short circuit at *c* of the $\lambda/4$ line *b*—*c*. Looking back from the output node *d* with diode D2 biassed on and effectively providing a short at node *c*, this combination of short circuit and $\lambda/4$ line *c*—*d* will exhibit a high impedance at node *d*.

This process is repeated in the other quadrants of the ring such that for a positive potential control bias quadrants *a*—*d* and *g*—*j* have minimal insertion loss whilst quadrants *d*—*g* and *j*—*a* have high isolation. The process is reversed when a negative potential control bias is applied.

Note that the control bias may be applied at any point in the ring configuration. Also, whilst the ring configuration shown has three $\lambda/4$ lines and two diodes in each quadrant the invention is not restricted to such specific number. It may be necessary to increase the numbers of lines and diodes in each quadrant to provide even more effective signal isolation between the input and output ports. Whilst it has been stated that the transmission lines are $\lambda/4$ in length, this is only a nominal length. In practice the lines may be shortened slightly to counteract the parasitic effects of the diodes. Typically the switch is fabricated as a stripline structure, the transmission lines being in the form of metal, e.g. aluminium, patterns on an insulating substrate.

As shown in Fig. 3 the switch 10 has its two inputs connected to a pair of spaced apart antennas 11a, 11b mounted on a rotatable boom (not shown). The outputs of the switch go to two identical radio receivers 12a, 12b the outputs of which are fed to a phase comparison computer 13. The phase difference between the received signals at the antennas can be translated into a bearing angle relative to the perpendicular bisector of the boom. This is a well-known technique used in navigation aids. However, such aids require careful calibration to reduce any errors inherent in the electronic equipment. To perform a calibration a switching control circuit 14 is included by means of which the two receiver channels can be alternated with the antenna signals so that the outputs can be balanced for a given input signal. The use of the switch structure shown in Fig. 1 allows such calibration to be performed with little or no phase errors being introduced by the switch.

CLAIMS

1. A solid state change-over switch arrangement for microwave signals comprising $4n$ identical transmission lines each of length $\lambda/4$, where λ is the incident signal wavelength, electrically connected in series in a ring configuration, with two input ports connected to two opposing nodes on the ring and two output ports connected to two opposing nodes on the ring, the input nodes being disposed orthogonally with respect to the output nodes so that each input node is electrically connected to each adjacent output node by a quadrant of n transmission lines, n being not less than 2, $4n-4$ PIN-diodes each connecting one of the nodes intermediate the input and output ports to ground, with the diodes in one pair of opposing quadrants being oppositely poled with respect to the diodes in the other pair of quadrants, and means for applying a control bias potential to the ring to effect switching of the diodes.

2. An arrangement according to claim 1 wherein each quadrant comprises three $\lambda/4$ transmission lines in series with two diodes connected to intermediate nodes.

3. An arrangement according to claim 1 or 2 wherein the transmission lines are fabricated as a stripline structure.

4. A solid state change-over switch substantially as described with reference to the accompanying drawings.

5. A direction finding navigation aid including a solid state changeover switch as claimed in any previous claim.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1983. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.